Report No. E6000-26

Quarterly Report No. 9

ENVIRONMENTAL STUDY OF MINIATURE SLIP RINGS

George C. Marshall Space Flight Center
Huntsville, Alabama

Report No. E6000-26

Quarterly Report No. 9

ENVIRONMENTAL STUDY OF MINIATURE SLIP RINGS

1 July 1965 to 1 October 1965

Contract No. NAS8-5251

Control No. TP3-83367 (IF)

IITRI Project E6000

Prepared by

IIT Research Institute
Technology Center
Chicago 16, Illinois

for

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Alabama 35812

Attn: PR-RDC

ENVIRONMENTAL STUDY OF MINIATURE SLIP RINGS

I. INTRODUCTION

This is the ninth quarterly progress report on IITRI Project E6000, "Environmental Study of Miniature Slip Rings." This report covers the activities during the period 1 July 1965 to 1 October 1965 and is the first quarterly report on the twelve month continuation authorized by Modification No. 6 of Contract No. NAS8-5251. The objectives of the new effort will be to evaluate slip ring materials and design techniques suitable for operation in high vacuum.

During the period reported herein, preliminary tests in high vacuum have been initiated. Brush-ring assemblies using new ring sleeves and brush blocks have been fabricated. Mass spectrometry studies relating to the off-gassing of materials used in new brush-ring assemblies have been started. Also, a run-in test of a capsule with a new brush design is being conducted in a nitrogen atmosphere.

II. HIGH VACUUM TESTING

The high vacuum facility used for the tests consists of the following: 24 x 24 in. steel chamber, refrigerated baffle, 10 in. NRC oil diffusion pump, and mechanical pumps. The nominal pumping speed of the diffusion pump is 1,700 liters per second at 10^{-5} torr. In order to prevent backstreaming of oil from the pump to the chamber, an optically dense refrigerated cold trap is placed between the chamber and the pump. The

operating temperatures of this cold trap are: -190°F inlet temperature and -130°F outlet temperature. The pressure is measured by means of an NRC type 507 ionization gauge. A vacuum of 10^{-7} torr can be achieved by this system.

A new mounting bracket was built to mount the capsule inside of the vacuum chamber. The magnetic drive used in previous tests had to be reworked to accomodate larger magnets because of the thicker glass in the vacuum chamber portholes. Several small holes were drilled into the capsule to prevent trapping of air inside of the capsule. A trial run was undertaken with Capsule 1-58 in a vacuum of 4×10^{-7} torr. After about one hour of operation, the capsule stopped and it appeared that the magnetic drive did not develop sufficient torque to rotate the capsule. After the vacuum chamber was pressurized, the capsule could again be driven. This was repeated two more times. It is assumed that the high vacuum operation of capsule and drive bearings causes a significant increase in drag torque. It was then decided that special vacuum bearings would have to be used. Several parts of the capsule and the drive system have been modified to permit use of commercially available vacuum bearings. Bar Temp bearings manufactured by Barden Corporation were selected because of their outstanding high vacuum performance characteristics. These bearings are equipped with cages made of a highly compressed material of teflon-coated glass fibers impregnated with molybdenum disulphide

(MoS_2). The one-piece cage serves both as a ball separator and as a source of dry lubricant. As the bearing rotates, the ball rubs off minute quantities of the lubricant, depositing a light coating on the raceways. Bearing rings and balls are fabricated of AISI 440C stainless steel, hardened and dimensionally stabilized by a special heat treating process. Partial delivery of the bearings has been made and the final delivery is scheduled for October 18, 1965.

An additional problem that was observed during the trial run was the high ambient noise level due to a variety of electrical equipment operating in close proximity to the test set up. Most of this problem was overcome by careful shielding and grounding.

III. NEW BRUSH-RING ASSEMBLIES

Ten experimental brush-ring assemblies were fabricated and goldplated. Different materials were used to minimize off-gassing at high vacuum. The ring sleeves were made of copper instead of brass. Brush blocks were machined from Mycalex 400. Mycalex is a trade name of glass-bonded mica made by Mycalex Corporation of America. It is certified as grade L432, precision-machinable material under MIL-I-10A specification for ceramic-grade electrical insulating materials and has excellent off-gassing characteristics.

Two experimental brush-ring assemblies were fabricated and forwarded to George C. Marshall Space Flight Center to be used in the in-house studies.

IV. ELECTROPLATING STUDIES

Plans have been worked out for the study of effects of electroplating. Over thirty experimental ring cylinders have been fabricated to be used in this study. Among the prime variables that will be investigated are the following: plating current density, hardening agents, and plating bath composition and temperature. In addition, some ring cylinders will be goldplated in a new plating tank in presence of supplementary ultrasonic energy (75 watts at 25 kilocycles). The effects of different parameters will be initially determined by taking microhardness measurements. The more promising types of electroplating will be further tested in capsules.

Several soft gold ring assemblies were machined with two types of hard gold overlays. One was Orotherm HT and the other Autronex NI. Both had a thickness of 100 microinches. The performance of these rings will be investigated in a nitrogen atmosphere.

V. INERT ATMOSPHERE TESTING

The object of inert atmosphere tests is the screening of different materials and designs. Slip rings that perform well will then be subjected to high vacuum tests. The drive apparatus and instrumentation developed during the original program is being used.

A run-in test is being presently conducted with a capsule using a new brush design. In this design two brushes have been cemented to the brush block to increase brush stiffness and prevent motion of brush wipers. This should improve the noise characteristics. The remaining two brushes on the same brush block were not modified so that a direct comparison of the noise performance of the two designs can be made.

VI. OFF-GASSING STUDIES

Preliminary studies relating to the off-gassing of three samples have been initiated by mass spectrometry. The ultimate objective of this work is to determine off-gassing under high vacuum conditions at ambient temperature. However, in order to obtain some qualitative information on the nature of such components, the samples were heated to elevated temperature to promote off-gassing.

The three samples included Mycalex 400, teflon wire insulation, and teflon ring sleeves.

In all cases, the total sample, after breaking or cutting into small pieces, was used for analysis. The sample was placed in the sample tube, affixed to the vacuum system of the inlet and pumped down for one minute at room temperature with the diffusion pump. The pumping was terminated and heating of the sample initiated. The sample was heated from room temperature to 120°C over a 5 minute period during which time the off-gas products were allowed to expand into the evacuated

sample reservoir. At the end of 5 minutes the sample was admitted to the analyzer for analysis over a mass range of m/e = 12-200. A blank was similarly run for comparisons.

Although the spectra for all of the samples are quite complex, the off-gas products for the teflon samples appear to be complex mixtures of fluorinated compounds and hydrocarbons. The wire insulation had a pronounced peak at m/e = 149 which is often characteristic of aromatic acids such as terephthalic acid or their esters. There was some lesser amount of this material in the teflon sleeve and no significant amount in the Mycalex 400. Mycalex 400 appeared to have predominantly hydrocarbon vapors. All samples off-gassed much air and water.

Additional samples will be analyzed at lower temperatures. The complexity of the off-gas mixtures will be minimized by gas chromatographic separation of the collected off-gass products to be followed by mass spectrographic analysis.

VII. LUBRICATION OF SLIP RINGS

An investigation of methods for lubricating slip ring assemblies has been initiated. The analysis and selection of candidate lubricants and lubrication techniques will be guided by work which is presently being conducted at IITRI in the areas of friction, wear and lubrication of components in a space environment. The basic concept of surface energy effects as related to friction and wear is applicable and practical selection criteria can be evolved with regard to the choice

of materials. It is felt that both liquid lubricants and low melting point metal film lubricants should be investigated.

The development of a lubricant system would necessarily include the development of a lubricant delivery technique. If the lubricant system is to be applicable for short term use, a one-shot delivery system would be a logical development; however, for a long term mission, a continuous or intermittent lubricant delivery technique would have to be developed. Also, additional problems arise if the lubrication system must be compatible with other environments in addition to the vacuum environment, for example, earth environment during check-out or low altitude operation.

After screening and selection of promising candidate lubricants and lubrication systems, experimental friction and wear studies will be conducted at pressures of 10^{-8} torr on simple flat plate and rider mechanisms. The apparatus shown in Figure 1 will be used for these studies. One or more of the most promising methods will then be investigated on actual slip ring assemblies.

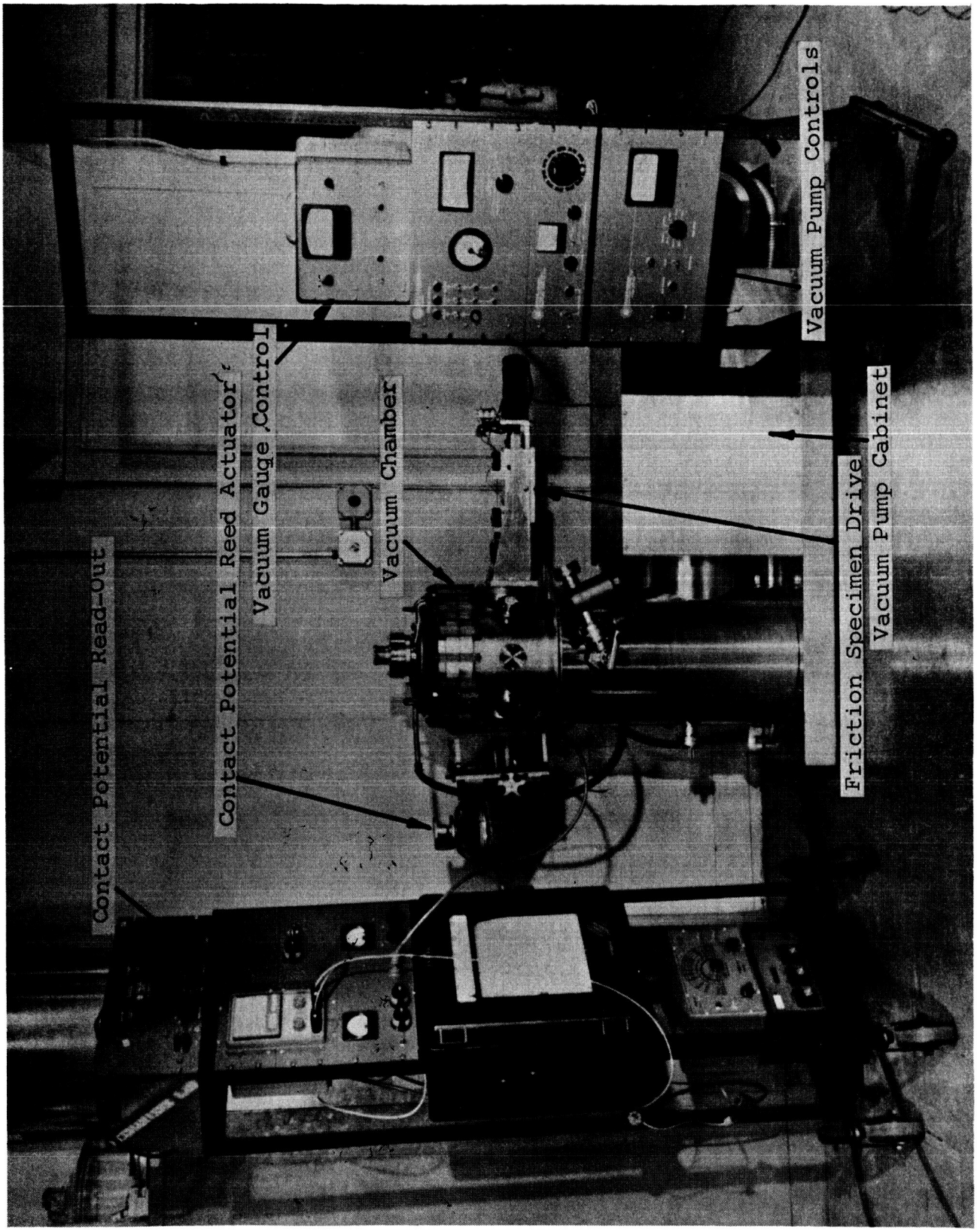

FIGURE 1 - ULTRAHIGH VACUUM FRICTION APPARATUS

VIII. SUMMARY

Preliminary tests in high vacuum proved the necessity of using vacuum bearings in the capsule and in the drive apparatus. New brush-ring assemblies using materials with good off-gassing properties have been fabricated. Run-in tests of a new brush design are being conducted in a nitrogen atmosphere. Mass spectrometer studies of the off-gassing products of materials used in the brush-ring assemblies have been started. A preliminary study of lubricants and lubrication techniques has been initiated.

IX. FUTURE ACTIVITIES

During the next quarterly period of this program, the following activities will be performed:

A. Run-in tests of new brush-ring assemblies in high vacuum will be initiated.

B. Study of effects of electroplating will be started.

C. Inert atmosphere tests of different brush designs and hard gold overlays will be continued.

D. Mass spectrometry studies of off-gassing products will be carried out at room ambient temperature.

E. Investigation of methods for lubrication slip ring assemblies will be undertaken.

X. PERSONNEL AND LOGBOOKS

IITRI staff members who have contributed to the research effort described in this report are J. L. Radnik, W. H. Graft, H. J. O'Neill, R. G. Scholz, W. J. Courtney, and M. Holzer.

The data on this project are recorded in logbooks C15698 and C14223.

Respectfully submitted,
IIT RESEARCH INSTITUTE

O. M. Kuritza

O. M. Kuritza
Research Engineer
Reliability and Components

Approved:

J. L. Radnik

J. L. Radnik
Assistant Manager
Reliability and Components